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CONTENTS

ARTICLES

Testing the weak-form efficiency of agriculture's capital markets

Binam Ghimire, Kolja Annussek, Jackie Harvey, Satish Sharma

The risk of the increasing divergence of the eurozone and the problem of macroeconomic imbalances in a three-gap model

Jacek Pera

Structural barriers to research and development activities in emerging markets: the case of Poland, the Czech Republic, Slovakia and Hungary

Anna Odrobina

Relationships and trust in perceiving price fairness: an exploratory study

Michael B. Hinner

Comparing consumers' value perception of luxury goods: Is national culture a sufficiently explanatory factor?

Beata Stępień, Ana Pinto Lima, Lutfu Sagbansua, Michael B. Hinner

Attitude toward luxury among Polish and Portuguese consumers

Wioleta Dryl, Arkadiusz Kozłowski

The institutionalization of practice: a processual perspective on value co-creation

Zofia Patora-Wysocka

The value of trust in inter-organizational relations

Małgorzata Chrupała-Pniak, Damian Grabowski, Monika Sulimowska-Formowicz

Improving student outcomes through the well designed use of computer technology in university business classes

Wendy Swenson Roth, Deborah S. Butler

BOOK REVIEWS

Robert B. Cialdini, Steve J. Martin, Noah J. Goldstein, *Mała wielka zmiana. Jak skutecznie wywierać wpływ* [*The small big. Small changes that spark big influence*], Gdańskie Wydawnictwo Psychologiczne, Sopot 2016 (*Henryk Mruk*)

Rodrik Dani, *Economics Rules. The Rights and Wrongs of the Dismal Science*, W.W. Norton & Company, New York 2015 (*Marzena Brzezińska*)

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Testing the weak-form efficiency of agriculture's capital markets¹

*Binam Ghimire,² Kolja Annussek,² Jackie Harvey,²
Satish Sharma²*

Abstract: This paper investigates the empirical validity of the weak-form Efficient Market Hypothesis [EMH] in global equity markets for agriculture. We examine whether developed agriculture markets are more efficient than emerging agriculture markets. We test six agriculture and food chain indices over the period of time between 2010 and 2013. The weak EMH was tested using the parametric Augmented Dickey-Fuller test as well as the non-parametric Runs test and Autocorrelation function test. The parametric test suggested some evidence for the existence of the weak-form EMH for all six indices in at least some of the five tested periods. However the non-parametric tests clearly proved the inefficiency of all indexes during all periods. Thus we finally rejected the null hypothesis for all indices in all periods. Accordingly agriculture's developed markets are equally inefficient and predictable as its emerging markets. The results of this work suggest that investors can achieve superior returns by investing in agricultural equity markets following a technical analysis and active portfolio approach. Thus this work is in great interest of investors and portfolio managers following an agriculture strategy. The study adds value to current research of market efficiency in developed as well as emerging markets.

Keywords: agriculture, efficient market hypothesis [EMH], autocorrelation, runs test, unit root test, random walk.

JEL codes: G1, C4.

Introduction

An efficient market cannot consistently achieve superior returns compared to average market returns on a risk-adjusted basis given the information publicly available at the time of investment. Fama's [1970] EMH provides three different versions of hypotheses: weak, semi-strong, and strong. The weak-form hy-

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pothesis claims that prices on traded assets [e.g. bonds or stocks] already reflect past publicly available information. The semi-strong form states that prices reflect all publicly available information, as well as that prices instantly change to reflect new public information. Finally, the strongest hypothesis affirms that prices instantly reflect even hidden or insider information. Since the research contributions of Fama [1970], there has been a great interest from investors, portfolio managers, financial analysts and standard setters as to whether markets exhibit random walk behaviour [Kothari 2001]. Investors are trying to assess a particular security by calculating market risk and as such they need volatility parameters that might affect their strategy. Volatility is described as the tendency of price changes of a security or asset. These changes or trends may be upwards as well as downwards. An increasing volatility indicates higher financial risk, which affects an investor's asset and may lead to the loss of confidence of an investor in a specific market. The knowledge of the degree of efficiency of market is supposed to provide confidence in the investor's chosen strategy [Hameed and Ashraf 2006].

The previously mentioned random walk behaviour, which forms the theoretical basis of the weak-form EMH, states that successive stock prices or returns are independently and identically distributed; that past stock prices have no predictive content to forecast future stock prices Godfrey, Granger, and Morgenstern [1964]. Statistically the random walk hypothesis [RWH], introduced by Godfrey, Granger, and Morgenstern [1964] is an independent test which poses the hypothesis that stock prices are characterised by a white-noise process, a stable first-order autoregressive pattern, a unit root process or a low correlation dimension. Over the last decades, there has been a large body of empirical studies concerning the validity of the weak-form EMH or RWH with respect to markets of developed countries as well as emerging countries. Empirical research, testing the randomness of the stock price series, has produced mixed results. For instance, most of the early research which focused on developed markets could prove the existence of the weak-form as well as semi-strong form. However recent studies have also reported that stock prices are predictable. With respect to emerging markets, the results vary amongst different countries. A few could find evidence for the existence of the RWH and weak-form EMH; however other studies have shown results that emerging markets seem to be predictable. Overall it is widely agreed in the literature that developed markets are more efficient than emerging markets, whereby emerging markets are about to become more efficient, according to some recent studies [Mobarek and Fiorante 2014].

Agriculture, the third largest market in the world after currency and energy markets, with a market chain value of \$6.7 trillion in 2011 [Lapérouse and Kiernan 2013], plays an important role in the world's economies (e.g. GDP growth) as well as sustainable development e.g. food security [World Bank 2007]. Not only because of the above mentioned reasons but also due to the

growing world population and simultaneously the increasing food demand several institutions (e.g. World Bank or FAO) emphasise the importance of investment in agriculture. It is also important to note that, although the investment in agriculture has distinctly increased over the last decades by private as well as institutional investors [Bergdolt and Mittal 2012], the actual investment is still low [Hallam 2011] meaning there is scope for this market to grow further.

Following the importance of an investment in agriculture, this study has been conducted with the motivation of providing further information for investors willing to invest in agriculture's equity markets. Since the knowledge of the degree of efficiency has a crucial impact on an investor's chosen strategy, we test the weak EMH on agricultural equity markets. In addition, we seek to add value to the current discussion in literature whether developed markets are still more efficient than emerging markets. Therefore we test daily prices of six developed and emerging agriculture and food chain indices on the weak EMH. We follow the methodology in the recent works of Vulic [2009], Jayakumar, Thomas, and Ali [2012], and Rehman and Qamar [2014].

The rest of the paper is organised as follows. Section 1 reviews recent studies on EMH with special emphasis on weak form EMH. Our methodology is explained in Section 2 and Section 3 describes the data. Section 4 discusses the findings and Section 5 concludes.

1. Literature review

The efficient-market hypothesis [EMH], officially introduced by the American economist Fama [1970], has been a cornerstone for financial economics [Alajbeg, Bubas, and Sonje 2012] and plays a significant role in the area of accountancy, financial analysis and also portfolio management [Kothari 2001]. According to this hypothesis the market is efficient if its prices are formed on the basis of all available information. A stock market is efficient only if all relevant information about a company is reflected in the stock price [Fama 1970]. Already, five years earlier, Fama [1965] had explained how the random walk hypothesis [RWH] represents significant challenges to the promoters of technical as well as fundamental analysis. Those that follow a technical analysis to find repeating patterns in individual securities will only find randomly occurring patterns if the market follows a random walk. In the case of the fundamental analysis, if the market is efficient and rational profit-maximisers are actively competing and important information is available to all participants, the intrinsic value forecast should be almost equal to the actual share price of a security. This is because all fundamental analysts would conduct their evaluation based on the same information.

Fama [1970] then stated three different types of efficiency; namely the weak-form, semi-strong form, and strong-form of efficiency. Where the strongest form

of efficiency is generally seen as too extreme researchers have focused on the semi-strong form by conducting event studies [Dupernex 2007]. Even though the semi-strong form could be proven it is not generally accepted that entire markets are semi-strong efficient [Shleifer 2000]. Since the emergence of behavioural finance during the last decades, which is the study of the behaviour of financial participants and may explain the inefficiency of markets by the irrationality of investors by certain behavioural heuristics [e.g. overconfidence or information bias, Shleifer 2000], the trend is towards an adaptive market hypothesis [AMH], where the weak-form may persist together with behavioural finance in a logically consistent way [Mobarek and Fiorante 2014].

The weak-form EMH is consistent with the RWH [Shleifer 2000] following the main premise that investors react instantly to any information they receive and thereby eliminate any chance of making superior returns. Consequently, prices are supposed to reflect all information available and no profits can be generated from information-based trading [Fama 1965; Lo and MacKinley 1999]. Thus the RWH states that the more efficient the market, the more random the sequence of prices [Dupernex 2007]. The RWH can be stated as $P_{t+1} = P_t + e_{t+1}$, where P_{t+1} is the price of the share at time $t + 1$, P_t is the price of shares at time t , and e_{t+1} is the random error, with zero the mean and finite variance. The RWH equation indicates that the price of a share at time $t + 1$ is equal to the price of a share at time t added with a value depending on the unpredictability of new information arriving between $t + 1$ and t [Kushwah, Negi, and Sharma 2013]. Thus a random walk is defined by the fact that price changes are independent of past price changes.

A large number of studies testing the weak-form of EMH have been conducted in the last decades, so it is important to note that in the following only a few studies are presented. Basically, those studies can be divided into those focussing on developed markets and others that focus on emerging markets. In addition studies have tried to rank countries on their efficiency by comparing developed and emerging markets.

1.1. Developed markets

With respect to developed markets earlier research had focused on the major markets such as United States of America and United Kingdom where most of studies found evidence for a random walk in these indices and thus, suggesting that the US and UK markets are weakly efficient [Cooper 1982]. More recent studies such as Andrews and Hellen [2010] or Adebayo [2013] support this view. Andrews and Hellen [2010] found that the European markets of Germany, Ireland, Portugal, Sweden, and also that of the UK had been following a random walk. However countries like Italy, Austria, Denmark or France, did not. Adebayo [2013] could clearly prove the weak-form efficiency for the UK between 2006 and 2011. However even if developed markets, such as the

US and UK markets, are perceived as being weak-form efficient, other studies also found evidence for the inefficiency of these markets. For instance Otilia [2011] studied the US, UK and also the Japanese market, between 1995 and 2010. Finally Otilia [2011] could not find evidence for a random walk in those indices over the inquiry period. Besides, studies focusing on the Asian developed markets came up with different results. Where Kim and Shamsuddin [2008] found the Hong Kong and Japanese market as weakly efficient during the year 1990, Hoque, Kim, and Pyun [2007] concluded that the Hong Kong market and Singapore markets were inefficient between 1990 and 2004. In contrast Lee, Lee and Lee [2010] examined the stationarity of real stock price series for 32 developed and 26 developing countries covering the period 1999 to 2007 and concluded that all stock markets were inefficient.

1.2. Emerging markets

With regard to emerging markets, Kim and Shansubbin [2008] studied Asian markets for the weak-form using data from 1990. They concluded that most of the emerging markets included were inefficient, except for Taiwan and Korea. Hoque, Kim, and Pyun [2007] studied eight different emerging markets in Asia in the period from 1990 to 2004. Their results were consistent with those of Kim and Shansubbin [2008] since most of the countries did not follow a random walk, except for Taiwan and Korea [Hoque, Kim, and Pyun 2007]. Additionally Wen, Li, and Liang [2010] tested China's capital markets and concluded that neither of the indexes (Shenzen and Shanghai) reached the level of weak-form efficiency between 2006 and 2009. In contrast Mobarek and Fiorante [2014] studied the market efficiency of BRIC countries between 1995 and 2010 and found evidence that these emerging countries are fairly weak-form efficient. Vulic [2009] studied the Montenegrin stock exchange index between 2003 and 2010 and found weak inefficiency. The same result could be found for the Mongolian market between 1999 and 2012 by Shawn et al. [2012] as well as for Pakistan between 2009 and 2010 [Rehman and Qamar 2014]. In contrast Asiri [2008] tested the stock exchange index of Bahrain for the weak-form between 1990 and 2000 and found evidence for weak efficiency. Buguk and Brorsen [2003], who studied the Istanbul stock exchange index, found only some evidence for the weak-form. However some statistical tests did not support the weak-form so that the weak-form could not be proven definitely for the period 1992 to 1999. In comparison Jafari [2013] found clear evidence that the Istanbul stock exchange index did not follow a random walk between 1997 and 2011. A few studies have also focused on the Indian stock market revealing different results. Jayakumar, Thomas, and Ali [2012] studied an Indian automobile index from 2007 and 2011 and found that this specific index did not follow a random walk. On the contrary Kushwah, Negi, and Sharma [2013] examined the main Indian stock exchange index and found evidence for its weak-form effi-

ciency between 1997 and 2011. The same result could be shown for the stock index of Bangladesh by Mobarek and Keasey [2000] between 1988 and 1997. Magnusson and Wydick [2002] studied eight different African markets such as Botswana, Ghana, Kenya, Nigeria, or South Africa, and found evidence for the weak-form in six of the eight African countries.

1.3. Developed versus emerging markets

With regard to studies that compared emerging against developed markets Cajueiro and Tabak [2004] examined whether emerging markets are becoming more efficient and studied 13 sample countries involving two developed countries (USA and Japan) and eleven emerging countries (e.g. Argentina, Brazil). The overall result was that developing countries are more efficient than emerging markets, whereas Asian countries were the least efficient. In comparison Risso [2009] compared 20 emerging and developed markets and concluded that the Asian markets of Taiwan, Singapore and Japan were the most efficient. The last positions were taken by the ex-socialist countries such as Russia and Slovenia. Major markets such as those of the US, UK, and Germany are ranked between six and ten. Another study conducted by Lim [2007] used data of eleven emerging and two developed markets from 1992 to 2005. The study clearly identified the two developed markets (US and Japan) as the most efficient. These results show the general trend of increasing efficiency in emerging markets [Hoque, Kim, and Pyun 2007; Kim and Shamsuddin 2008; Mobarek and Fiorante 2014] which might be evidence for the AMH that efficiency can evolve over time [Lim 2007].

2. Methodology

We followed the approach of Vulic [2009], Jayakumar, Thomas, and Ali [2012], and Rehman and Qamar [2014] by applying three common statistical tests to assess the weak form of efficiency for agriculture indexes globally; namely the augmented Dickey-Fuller test [ADF], the runs test, as well as the autocorrelation function [ACF] test.

2.1. Augmented Dickey-Fuller

The ADF test is the most popular stationary test [Bollerslev and Hodrick 1999; Buguk and Brorsen 2003]. The test will be used to test the unit root hypothesis. If a one time series has a unit root it means that it is not stationary and that it does follow a random walk [Vulic 2009]. The test is based on the following three regression models [Dickey and Fuller 1981]:

$$\text{Model I: } \Delta y_t = \delta Y_{t-1} + \beta \sum_{i=0}^p \Delta y_{t-i} + u_t, \quad (1)$$

$$\text{Model II: } \Delta y_t = c_0 + \delta Y_{t-1} + \beta \sum_{i=0}^p \Delta y_{t-i} + u_t, \quad (2)$$

$$\text{Model III: } \Delta y_t = c_0 + c_1 t + \delta Y_{t-1} + \beta \sum_{i=0}^p \Delta y_{t-i} + u_t. \quad (3)$$

The ADF test assumes that the y series follows an $AR[p]$ process and adds p lagged differences in terms of the dependent variable y to the right side of the test regression. Model I does not include an intercept [drift] or trend terms. Model II does include a constant whilst model III includes a constant term as well as a trend term [Jafari 2013: 175].

The hypotheses for the ADF are the following:

H_0 : There is a unit root in the time series,

H_1 : There is no a unit root in the time series.

2.2. Runs test

The runs test, also known as the Wald-Wolfowitz test or Geary test [Rehman and Qamar 2014], is a very well-known non-parametric statistical test whereby the number of sequences of consecutive positive and negative returns is tabularised and compared against its sampling distribution, under the RWH [Vulic 2009]. A run is defined as the repeated appearance of the same value or category of a variable [Geary 1935]. Basically, a run consists of two parameters, the type and the length of the run where runs of stock prices can be positive, negative or unmoved [Rehman and Qamar 2014]. The length is defined by how often a run appears in a sequence. The null hypothesis underlies the assumptions that continuous outcomes are independent and the total expected number of runs is normally distributed with a mean defined as

$$\bar{X} = \frac{n + 2n_0 \cdot n_1}{n} \quad (4)$$

and the standard deviation as

$$\sigma = \sqrt{\frac{2n_0 \cdot n_1 [2n_0 \cdot n_1 - n]}{n^2 [n - 1]}}. \quad (5)$$

The variable n is the total number of observations, n_0 is the number of first run cycles and n_1 is the number of second run cycles. The total number of runs is marked with R . The runs test assumes a normal distribution if the total num-

ber of observations is high [Vulic 2009]. The test for the serial dependence is executed by the comparison of the actual number of runs R and the expected number runs $E[R]$ in the price series. The hypotheses can be stated as:

H_0 : Number of Runs $[R]$ = Number of expected Runs $E[R]$,

H_1 : Number of Runs $[R] \neq$ Number of expected Runs $E[R]$,

where the null hypothesis investigates a randomness hypothesis for a two-valued data sequence [Jayakumar, Thomas, and Ali 2012]. Consequently it tests whether the elements of the sequence are mutually independent. Since the runs test presumes a normal distribution if the total number of observations is high the standard normal distribution Z can be applied [Vulic 2009; Rehman and Qamar 2014]. The Standard Score is defined as $Z = \frac{R - E[R]}{\sigma}$. If the calculated

Z value is greater than the critical value at the appropriate significance level the null hypothesis is rejected and it can be concluded that the examined market cannot be predicted [Vulic 2009; Jayakumar, Thomas, and Ali 2012; Rehman and Qamar 2014].

2.3. Autocorrelation function

The ACF test is the most commonly used tool for randomness and will be used to identify the degree of autocorrelation in the price series [Jayakumar, Thomas, and Ali 2012]. The ACF examines the correlation between the current and the lagged observations of the price series. If this series has a unit root, the ACF value will slowly beginning to decrease [<0] and the partial correlation function [PACF] has only a first value which differs from zero. If one price series has two unit roots, the ACF value will act in the same way as for the one unit root series, whereby the PACF has only the first two nonzero values [Vulic 2009; Jayakumar, Thomas, and Ali 2012]. The hypotheses are defined as below:

H_0 : $P_k = 0$ [price changes are independent],

H_1 : $P_k \neq 0$ [price changes are not independent].

Where P_k is calculated as presented in the equation below. K is defined as the number of lags and R_t presents the real rate of return [Rehman and Qamar 2014].

$$P_k = \frac{\sum_{t=1}^{n-k} (R_t - \bar{R})(R_{t+1} - \bar{R})}{\sum_{t=1}^n (R_t - \bar{R})^2}. \quad (6)$$

3. Data

For our aim of testing agriculture's equity markets on the weak EMH as well as to further investigate whether there are differences between developed and emerging markets, we analysed a sample of six different regional agricultural

and food chain indices provided by MSCI Inc. Four of those six indices represent developed markets whereas the other two are emerging markets. The MSCI Agriculture & Food Chain Indexes are designed to track the performance of listed companies that are producers of agricultural products, fertilisers and agricultural chemicals, packaged food and food distributors [MSCI 2008]. The agricultural and food chain EAFE index (EAFE) represents 21 countries from Europe, Australia and the Far East (EAFE). The European index (EUROPE) tracks the performance of 15 European countries. The Pacific index (PACIFIC) presents the countries of Australia, Hong Kong, Japan, New Zealand and Singapore. The USA is the only country specific index representing the United States of America (USA). With regard to emerging markets, the EM embodies 23 different worldwide emerging markets and the BRIC index covers the economically important countries of Brazil, Russia, China and India (BRIC). We collected daily prices (Monday to Friday) from 31-12-2009 till 31-12-2013 which is 1044 days. Prices are denominated in US-dollars and have been directly downloaded from the MSCI webpage. We conducted a cross-sectional as well as longitudinal study where the longitudinal is made with respect to the AMH that efficiency can evolve over time [Lim 2007]. Accordingly we tested the five periods that are reported in Table 1.

Table 1. Test periods and number of observations

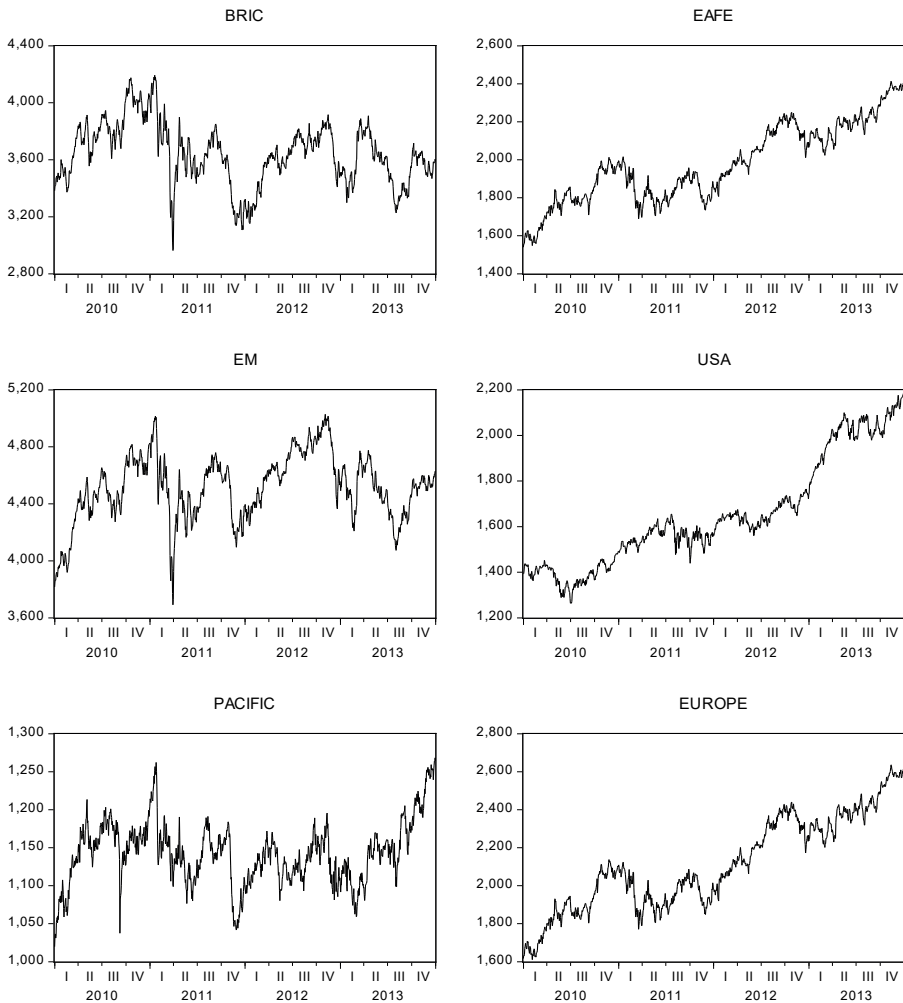
Period	Number of days
Dec 31st 2009–Dec 31st 2010	262
Dec 31st 2010–Dec 31st 2011	261
Dec 31st 2011–Dec 31st 2012	262
Dec 31st 2012–Dec 31st 2013	262
Dec 31st 2009–Dec 31st 2013	1044

4. Results

Figure shows the performance of various indices between 2010 and 2013.

It can be seen in Figure that developed markets enjoy a clear upward trend compared to the emerging markets. Further, the indices of the emerging economies have slower growth and they show distinct downside movements over the period studied. We therefore tested the second and third model of the ADF test assuming a constant as well as a constant with trends. The results are shown in Table 2.

According to the ADF test (Table 2) the results suggest a non-stationarity for all indices in at least some periods. The major developed indices, EAFE and Europe, even reveal evidence for a random walk in all five test periods.



Index Performance 2010–2013

In contrast the two emerging market indexes expose a non-stationarity in all longitudinal periods but not in the long period. Finally, the ADF test results lead to the acceptance of the null-hypothesis for most of the periods studied.

Table 3 and Table 4 show the results of the runs and autocorrelation function results respectively.

The runs test (Table 3) as well as the ACF test (Table 4) results clearly prove the inefficiency of all six indices in all five periods. The runs test presents high Z-values for all indices in all periods, which in turn leads to very low p-values and the rejection of the null-hypothesis. The ACF test exposes a declining ACF value with a high Q-static value for all indices in all periods which is clearly a sign of a positive correlation. Thus the ACF test does not support the non-

Table 2. Augmented Dickey-Fuller results

ADF	Period 1		Period 2		Period 3		Period 4		Period 5	
	Model II	Model III	Model II	Model III	Model II	Model III	Model II	Model III	Model II	Model III
	<p(.05)- 2.8724	<p(.05)- 2.8724	<p(.05)- 2.8724	<p(.05)- 2.8724	<p(.05)- 2.8724	<p(.05)- 2.8724	<p(.05)- 2.8724	<p(.05)- 2.8724	<p(.05)- 2.8724	<p(.05)- 2.8724
EAFE	-1.3381	-3.1625	-2.8308	-2.7388	-1.9056	-1.2510	-1.4001	-3.6549	-1.5580	-3.4281
EUROPE	-1.1848	-3.0719	-2.8814	-2.8404	-1.8650	-1.3026	-1.4898	-3.7620	-1.4303	-3.5303
PACIFIC	-3.2832	-3.7119	-2.2992	-2.5840	-3.7848	-3.7306	-0.7470	-2.7252	-4.3663	-4.4109
USA	-1.3991	-1.5909	-3.8271	-3.8204	-1.9926	-2.7981	-2.3310	-3.1492	0.0563	-2.6403
EM	-1.7910	-2.8450	-2.8896	-2.8665	-1.7357	-1.0270	-1.9706	-1.9243	-4.0697	-4.0521
BRIC	-2.0529	-3.3097	-2.6141	-3.1948	-1.9034	-1.3785	-2.0169	-2.0669	-3.7855	-4.0839

Table 3. Runs test results

Economies/ Region	Runs Test Variables	Period 1	Period 2	Period 3	Period 4	Period 5
EAFE	Z-Value	-14.11	-14.69	-15.6	-14.31	-31.02
	P-Value	.000 <.05	.000 <.05	.000 <.05	.000 <.05	.000 <.05
EUROPE	Z-Value	-14.6	-14.2	-15.6	-13.82	-31.26
	P-Value	.000 <.05	.000 <.05	.000 <.05	.000 <.05	.000 <.05
PACIFIC	Z-Value	-13.69	-12.59	-11.74	-14.33	-26.32
	P-Value	.000 <.05	.000 <.05	.000 <.05	.000 <.05	.000 <.05
USA	Z-Value	-14.47	-12.09	-13.56	-13.84	-31.19
	P-Value	.000 <.05	.000 <.05	.000 <.05	.000 <.05	.000 <.05
EM	Z-Value	-13.69	-12.59	-11.74	-14.33	-26.32
	P-Value	.000 <.05	.000 <.05	.000 <.05	.000 <.05	.000 <.05
BRIC	Z-Value	-14.1	-14.31	-13.93	-15.1	-28.73
	P-Value	.000 <.05	.000 <.05	.000 <.05	.000 <.05	.000 <.05

stationarity of the indexes discovered in some periods with respect to the ADF results. The ACF results go hand in hand with the runs test’s results suggesting the non-randomness of the agriculture and food chain indices. The indexes can be predicted by following the positive correlation. Finally, we reject the null-hypothesis for all indices in all periods, since the runs test and ACF test do not support the ADF test results. Simultaneously we conclude that agriculture’s developed and emerging markets are equally inefficient. Noticeably, since the results of ADF indicates signs of efficiency for all indexes, a comparison reveals

Table 4. Autocorrelation function results

	ACF Variables	Period 1	Period 2	Period 3	Period 4	Period 5
EAFE	ACF-Value	0.236	0.061	0.482	0.258	0.662
	Q-Static	3857.5	2133.5	5725.8	3590.2	25912
	P-Value	.000 <.05	.000 <.05	.000 <.05	.000 <.05	.000 <.05
EUROPE	ACF-Value	0.226	0.071	0.489	0.256	0.689
	Q-Static	3831.1	2154.7	5804.8	3579.5	26849
	P-Value	.000 <.05	.000 <.05	.000 <.05	.000 <.05	.000 <.05
PACIFIC	ACF-Value	0.151	0.057	0.02	0.242	0.019
	Q-Static	2553.9	1711.4	1275.9	2844.3	10307
	P-Value	.000 <.05	.000 <.05	.000 <.05	.000 <.05	.000 <.05
USA	ACF-Value	0.18	0.271	0.164	0.184	0.755
	Q-Static	2675.3	1375	2482.8	2673	28365
	P-Value	.000 <.05	.000 <.05	.000 <.05	.000 <.05	.000 <.05
EM	ACF-Value	0.172	0.074	0.34	0.05	0.399
	Q-Static	2565.7	1860.2	4511.4	2692.3	17603
	P-Value	.000 <.05	.000 <.05	.000 <.05	.000 <.05	.000 <.05
BRIC	ACF-Value	0.172	0.074	0.34	0.05	0.399
	Q-Static	2565.7	1820.2	4511.4	2692.3	17603
	P-Value	.000 <.05	.000 <.05	.000 <.05	.000 <.05	.000 <.05

some evidence that agriculture’s developed markets seem to be more efficient, especially by comparing the two major developed indexes, EAFE and Europe, with the major EM emerging market index. The summary of the results of the tests above can be seen in Table 5.

Table 5. Summary of test results

Eco- nomies	Period 1			Period 2			Period 3			Period 4			Period 5		
	ADF	RT	ACF	ADF	RT	ACF	ADF	RT	ACF	ADF	RT	ACF	ADF	RT	ACF
EAFE	✓	×	×	✓	×	×	✓	×	×	✓	×	×	✓	×	×
EUROPE	✓	×	×	✓	×	×	✓	×	×	✓	×	×	✓	×	×
PACIFIC	✓	×	×	×	×	×	✓	×	×	✓	×	×	✓	×	×
USA	×	×	×	✓	×	×	×	×	×	✓	×	×	×	×	×
EM	✓	×	×	✓	×	×	✓	×	×	✓	×	×	×	×	×
BRIC	✓	×	×	✓	×	×	✓	×	×	✓	×	×	×	×	×

Conclusions

In this paper we tested the weak EMH on six regional agricultural and food chain indices over the period 2010–2013. The parametric test suggested some evidence for the existence of the weak-form EMH for all six indices in at least some of the five periods tested. However the non-parametric tests clearly proved the inefficiency of all indexes during all periods. Thus we finally rejected the null hypothesis for all indices in all periods. Accordingly, agriculture's developed markets are equally inefficient and predictable as its emerging markets suggesting possible superior returns through investing in agriculture's equity markets.

Overall our results are consistent with previous studies. Nevertheless it is important to note that we tested specific indices and not major country related stock exchange indices as in most of the other studies, so that finally the inefficiency may be related to the specific asset class. Additionally our sample consists of indices that represent several different countries, so that an inefficient country may affect the overall efficiency of an efficient country. This is in relation to the general criticism of using indices as time series to test the RWH, since indices may give a completely false impression of the extent of price fluctuations due to multiple share representation. Additionally we used daily data which is exposed with the risk of market anomalies leading to the possible conclusion that the inefficiency may be explained by behavioural finance. Accordingly we recommend that future research be focussed on the application of different and more robust tests for different time series and input data (e.g. weekly data). Since the inefficiency of markets may be explained by behavioural finance, future research may also focus on market anomalies.

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